Please read and send in as full a discussion as possible at earliest date.

Canadian Society of Civil Engineers.
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ADVANCE PROOF—(*Subject to revision*).

N.B.—This Society, as a body, does not hold itself responsible for the statements and opinions advanced in any of its publications.

The following specification was drawn and compiled by the writer to comply with the general specification of the Provincial Engineer of Nova Scotia and of the Canadian Department of Railways and Canals in force in 1899, so that some of its provisions are thereby governed.

The whole is submitted with the object of drawing out discussion and eliciting improved renderings and additions such as would be applicable to a general railway specification; and looking to the possibility, perhaps, of the Society appointing a committee to formulate a standard specification, with or without alternative readings applicable to different circumstances or parts of the country.

J. S. Armstrong, M. Can. Soc. C.E.

SPECIFICATION.

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GENERAL.

This specification refers to the works, easements and things required for the construction, equipment and maintenance of the 1
Railway, with its branches, terminus and shipping facilities, comprising fencing, grading, bridging, ballasting and track (including 80 lb. rails and fastenings) points 2
crossings, switches, signals, turnouts, sidings, station buildings and yards, offices, machine shops, engine houses, turntables, water tanks and water services with all machinery and fittings, wharves, warehouses and all other works of every description which may be necessary to the completion of the work according to the following specification, and to such supplements thereto, and the plans, surveys and instruction that may, from time to time, be added by 3
the Company's engineer during the progress of the work and until the final estimate of the whole work, or final estimates, part by 4

part, as by contract may be determined, is or are issued by the Company's engineer; the said works having been accepted and passed by the duly authorized authorities of the Dominion and Local Government in as far as they are interested.

Lands.

The lands required by the Company for tracks or station purposes, for the line of railway and branches, sidings, stations, wharves or piers, as contemplated by the Company's charter, will probably be granted to the Company, and will not, in that case, come under this contract or specification. But all lands or material therefrom, required and otherwise taken for the use of the Company, may be taken and paid for under contract, but the contractor shall enclose all grounds delivered to him for the purpose of this contract, with a good fence wherever required, and shall keep the same enclosed, during the progress of the work, until the termination of the contract, including the period of maintenance, so as to effectually preserve the adjoining lands from trespass, and prevent any injury whatever to any parties by reason of the want of sufficient fences to separate their lands from the works, and the contractor shall be wholly responsible for all damages to crops and all the consequences of insufficient fences.

Words defined.

In the following specification the word Company shall mean the Railway Company, Limited, represented by its President or General Manager, and the word Engineer shall mean the Chief Engineer of the Railway Company, Limited, or his duly authorized assistants, whether engineers or inspectors.

Alterations.

The engineer shall, at any time, either before the commencement or during the construction of any portion of the work, be at liberty to make any alterations or change that he may deem advisable, either in the grades or alignment, the width of cuttings or embankments, the dimensions or character of structures, or in any other thing connected with the works, whether the same increases or diminishes the quantity; and the contractor shall only be allowed at the same rate as in his schedule of prices, and no extras of any description will be allowed except on the order of the engineer in writing.

Schedule, prices cover all details.

The rates and prices in the schedule must be understood to include not only the particular work or material mentioned, but all and every kind of work, labour, tools, plant and material, of whatsoever kind necessary, for the full execution and completion, ready for use, of the respective portions of the work, to the satisfaction of the engineer.

The contractors shall carry on the works at such places and in such manner as he shall be directed from time to time by the Engineer.

The contractor shall be held responsible for all work that may prove defective, owing to bad material or workmanship provided by him, or through want of proper precaution, previous to the granting of the final certificate. Responsibility. 20

If, at any time, the number of workmen or horses, or the amount of material or other plant shall, in the opinion of the engineer, be insufficient for the due completion of the works in the time specified, or if the works are, or some part of them is, not being carried on with due diligence, then in every such case the said engineer shall have the power to notify the contractor in writing to employ or provide such additional workmen, horses, material or plant as the said engineer may think necessary, and, in case the contractor shall not thereupon within three days, or such longer time as may be fixed by any such notice, in all respects comply therewith, he, the said engineer, shall have the power to provide any workmen, horses, material or plant he may think proper, and all moneys so expended by the Company shall thereupon be repaid by the contractor, or may be deducted or detained out of any moneys due, or to become due, to the contractor, and, should these moneys be insufficient, the balance shall be recoverable in the usual way as a debt due by the contractor to the Company. 21 Engineer may increase forces 22

In case any material is, in the opinion of the engineer, not in suitable accordance with the terms of the contract, and is condemned as unsuitable or inferior, it shall at once be removed by the contractor from the works, or, should this not be done, the engineer may, on giving three days' notice, cause the same to be removed, and the cost of such removal shall be deducted from any moneys due, or to become due, to the contractor. 23 Engineers may remove improper materials.

If any work or service be required to be done, which is not named in the schedule of prices, or otherwise provided for, the engineer shall be at liberty to direct the contractor to perform the same, paying him the actual cost of any such work or material, with an addition of ( ) per cent. to cover the use of tools and profit. 24 Extra work.

In the absence of the contractor a competent agent or foreman shall represent him on the works, who shall be considered the lawful representative of the contractor, and any orders given to such agent or foreman shall be deemed given to the contractor. 25 Contractor's representative.

The Company will provide the necessary land for the right of way of railway and wharves or piers, but the contractor will have to provide, at his own cost, any other land required for procuring material or conducting his operations, the powers of the Company being available therefor. 26 Lands other than provided by Co.

When considered necessary by the engineer, detailed drawings of the different structures will be furnished to the contractor, from time to time, as the work progresses, and the work shall be done in accordance therewith. 27 Work to drawings, etc.

Payments. Cash payments, equal to 90 per cent. of the work done and material done, approximately made up from returns or progress measurements, and computed at the schedule prices, shall be made to the contractor monthly, on the written certificate of the engineer that the work, on account of which the certificate is granted, has been executed to his satisfaction.

Drawback. The remaining ten per cent. shall be retained until the final completion of the whole work to the satisfaction of the engineer, and shall be paid within two months after the granting of said final certificate; but such progress measurements or certificates shall not in any respect be taken as an acceptance of the work or the release of the contractor from responsibility in respect thereof, but he shall, at the conclusion of the work, deliver over the same in good order.

Wages. The wages of all persons, of any class, employed upon or in respect of any of the said works, shall be paid, at least, once a month. If possible, said payments shall be made upon the works, or some point convenient to the same, but in no case at a tavern or other place where liquors are sold.

Taverns. The contractor, or any person directly or indirectly employed by him, shall in no case establish any tavern or store or other place for the supply of liquor or any intoxicating drinks.

Right to enter. The Company retains the right to enter upon the works at any time, and to carry on any work that may be considered necessary by the engineer, in order to erect (the iron superstructure of the bridge or) any other work that may be required by the Company; and it is understood that this taking possession (of the piers and abutments as they are ready for the superstructure, or other postions of the work) is not to be considered a final acceptance of the work thus taken possession of.

Damage. The contractor shall be held responsible for any damage done by himself, or any parties in his employ, to property adjoining the railway.

Mechanics. The contractors shall employ mechanics for every species of mechanical work.

Masons. No masonry, other than concrete, of any quality shall be laid by other than masons who have served their time as such.

Obedience. The employees of the contractor shall, at all times, obey the directions of the engineer, or his deputies, with respect to the work; and if any overseer, agent or workman of the contractor shall be found unfaithful or incompetent by the engineer, or shall neglect or refuse to obey all reasonable orders of the engineer or his deputies, or shall have promoted disturbance upon the work, the contractor shall, on being required to do so by the engineer, at once discharge said person, and shall no longer employ him on the work.

Extra work. No allowance will be made for extra work except upon a writ-

ten agreement signed by the contractor and the engineer, or under the written order of the engineer.

41 Claims. All claims for extra work, so ordered, must be made to the engineer in writing before the payment of the next succeeding estimate after the work is performed, and failing to make such claims the same shall be considered as abandoned by the contractor.

42 Sublet (Materials) The contractor shall not be permitted to sublet any portion of this work without the consent of the Company and their approval of the sub-contract.

43 Which consent or approval, however, shall by no means be considered a recognition of such sub-contractor.

44 Contractors office. The contractor shall be bound at all times to have an office on the works or at , where, by himself or some authorized agent, all notices or requisitions from the Company or the engineer may be received or acknowledged.

45 Grades bench marks. All grades, dimensions, etc., will be given by the proper stakes and bench marks. Such stakes and bench marks must be preserved by the contractor until the prosecution of the work requires their removal.

46 Liable for cost of replacing. If the contractor, in a careless or wilful manner, causes the removal of the said stakes or bench marks before the prosecution of the work requires it, the expense of replacing them will be charged to the contractor, and amount deducted from the amount due on his final estimate.

47 Delays. The Company will use due diligence in securing the right of way, but will not be responsible for delays in this connection. All such delays shall only have the effect of entitling the contractor to additional time for the completion of the work, the engineer to be the judge as to the loss of time and the additional time to be allowed to the contractor for the completion of his contract.

48 Engineer judge. All works are to be done to the entire satisfaction of the engineer. He is to be the sole judge of work or material, in respect both to quality, quantity and classification, and his decisions on all questions of dispute with regard to work or materials, or as to the meaning or interpretation of the plans or specification, is to be considered final and binding on all parties.

FENCING.

49 All wood, brush, etc., must be cut, removed from the site of the fence and burned. No rubbish of any kind must be left strewn about the ground.

50 Sills. If barbed wire fencing is ordered, sills will be of round cedar or hackmatack six inches at the smaller end and nine feet long, and sunk in the ground six inches.

Posts. 51 Posts, when used with sills, will be of round cedar or hackmatack six inches at the smaller end and five feet long.

Braces. 52 Braces will be of round cedar or hackmatack five inches at the smaller end and three and a half feet long.

Spacing. 53 Dovetailed two inches into side of sills and post and fastened with two six inch spikes. Small ends of posts to be placed upper-

Framing. 54 most. Braces to be let into posts and fastened with two six inch spikes at each end.

Top board. 55 There will be a top board five inches wide and one and one-half inches thick, spiked vertically to the top of the posts on the side farthest from the track, for the barbed wire fence. The top boards to be ten or twenty feet long, so as to abut on posts, and fastened as above.

Barbed wire. 56 Four best galvanized barbed wire strands are to be stretched on outside of post farthest from the track, properly secured with

57 staples to each post. Each strand to be of two twisted wires, and each barb to have four points, the wire to be No. 12 steel.

Straining posts. 58 Straining posts are to be put up every two hundred feet and at all angles and gate openings, and the fence drawn up tightly. The straining post will be sunk in the ground at least four feet. They

59 will be braced both ways, from top of post to foot of adjoining post, with three inch round cedar braces fastened with two six inch spikes at each end.

Posts set on ground. 60 Or the fence may be built by letting the posts into the ground. Posts to be of round cedar or hackmatack six inches at the small end and eight feet six inches long, placed four feet in the ground and ten feet apart centres.

61 All posts to have the top cut off at an angle of 45.

Other specifications. 62 Fence, other than barbed wire, with different spacing of posts, may be substituted on the specification and order of the engineer.

Gates. 63 Farm gates to be constructed as per detailed drawing to be furnished by the engineer.

Material. 64 All the material shall be of sound merchantable stock, and the round sticks shall be of green wood, stripped of bark.

GRADING.

Clearing. 65 Where the line passes through wooded land, the entire right of way shall be cleared of all the timber, brush, stumps, etc., which shall be either burned or removed from the right of way.

66 No timber, brush, stumps or roots shall in any case be piled upon adjacent lands.

Close cutting. 67 Where embankments are less than four feet (4) and more than two (2) feet, all trees and stumps are to be cut off close to the ground.

Where embankments are more than four (4) feet high all trees shall be cut so that the top of the stumps shall always be, at least two (2) feet below sub-grade. In excavations less than three (3) feet and embankments less than two (2) feet all trees and stumps must be grubbed out within the limits of such cuttings, ditches, drains or embankments; but in no case shall grubbing be paid for in burrow pits or in excavations more than three (3) feet in depth. 68 69 Grubbing. 70

Many parts of the line have been burned over years ago, and other parts are over barrens and bogs where there is little or nothing but light brush and the clearing. Close cutting or grubbing will be proportionately light. It will be classified as light or full clearing, grubbing and close cutting, according to the judgment of the engineer. 71 72 Partial clearing, etc.

In swamps or soft places, if so desired by the engineer, a crossway of logs of such breadth as he may direct shall be constructed of a depth of one (1) foot, or such greater depth as may be considered necessary. Said logs to be placed close together, and to be no less than six (6) inches in diameter at small end and finally closely covered with brush. No ditches to be made on either side of such crossway, unless with the direction of the engineer. The work shall be paid for at so much per acre on a basis of one (1) foot in depth of timber. 73 Crossweying.

EXCAVATION.

The width of embankments at sub-grade or formation level will be fifteen (15) feet. 74

The width or cuttings will not be less than twenty (20) feet.

The slopes of earthwork will generally be made one and a half horizontal to one perpendicular. In rock cuttings the slopes will be, as a rule, one horizontal to four perpendicular. In cuttings partly earth and partly rock, a beam of six feet must be left on the surface of the rock. The widths, slopes, and other dimensions, above defined, may be varied by the engineer at any time to suit the circumstances. 75 Dimensions. 76

On side hill grounds, where embankments are to be built, and upon which the new work would, in the opinion of the engineer, have a tendancy to slide, the surface shall be stepped or deeply ploughed before commencing the embankment, as may be directed by the engineer. 77 Stepping side hills.

The materials to be placed in the embankments must be approved by the engineer. All materials found in excavation, whether in road bed cuttings, ditches, water channels, road crossings or elsewhere, must be deposited in embankment or such places as the engineer may direct. 78 Materials.

Borrowing. 79 In cases where the road bed excavations are insufficient to form embankments the deficiency shall generally be made up by widening the cuts and by putting ditches through them; but there may 80 be special cases where other means of obtaining material for embankments will be permitted or ordered by the engineer, but in no case will the contractor be allowed to borrow without the consent in writing of the engineer.

Wasting. 81 No wasting on the sides of the cuttings or on the sides of the ditches will be allowed. Where there is an excess of excavation this surplus must be used in widening the embankments, or for such other purposes as the engineer may direct.

Offtakes. 82 In level sections it will be necessary to excavate off take ditches for considerable distances to the right and left of the line. These ditches will generally be required in the lowest ground, and must be of sufficient widths and depths to fill the requirements of thorough drainage, and their sides shall be sloped, and they shall be completed to the satisfaction of the engineer.

Ditching. 83 On the completion of the cuttings, ditches for the removal of the surface water shall be formed at the bottom of the slopes and at the mouths of cuttings, turned out so as not to waste the embankment on land sloping towards cuttings or embankments.

Catchwaters. 84 Catchwater ditches shall be formed some distance back from the top of the slopes of cuttings and foot of embankments, to exclude any water flowing from adjoining land. The contractor shall

Drains. 85 also construct all other drains and ditches which the engineer may deem necessary for the perfect drainage of the railway and works. All ditches shall be graded so as to continuously carry off any water.

Diversions. 86 The contractor shall also make all necessary diversions of roads and streams as directed by the engineer.

Allowance for shrinkage. 87 The embankments must be made to such height and width as will allow for subsidence of same, so that on being trimmed, after the whole line is completed, they will stand at the full dimensions specified in clause 74, and in accordance with general drawings furnished by the engineer.

88 The whole of the grading shall be carefully formed to inclinations and levels approved by the engineer, and the roadway and cuttings shall be invariably rounded and left from six to eight

89 inches lower at the sides than on the centre line. For rock cuttings it will be sufficient to form a water channel about two feet wide, eight inches deep, along each side.

Berm. 90 Side burrows and ditches, except where they connect with cuttings, shall be made so that a berm of four feet, and a further allowance for slope of one and a-half to one (1), shall be left outside the foot of the embankment.

Em' above waters levels. 91 The formation level or sub-grade of the embankment, running through intervals or along streams, must not be less than one (1)

foot higher (after due subsidence has taken place) than the highest freshet or tide known in these streams or rivers. If, before the whole contract is completed, any portion should be found too low it will have to be raised and embanked anew so as to be above the levels named.

Under draining see end of structures.

CLASSIFICATION.

1. Solid rock will include all rock found in ledges, or in masses of more than one (1) cubic yard, which, in the judgment of the engineer, may be best removed by blasting, with the exception of ledge rock described under the head of loose rock and gypsum. — Solid Rock.

2nd. Gypsum in a solid compact state which requires blasting to move it. — Gypsum.

3rd. Loose rock shall include all kinds of shale, soap stone and other ledge rock, which, in the judgment of the engineer, can be removed with pick and bar without blasting; also detached stones measuring less than one (1) cubic yard and over two (2) cubic feet. — Loose Rock

4th. Hardpan or gumbo shall include all excavation other than solid rock, gypsum and loose rock that, in the judgment of the engineer, cannot be *readily* worked with pick and shovel, or, after being ploughed with as many as four strong horses on the plough, is not *readily* shovelled or scraped. But if, through fault of the contractor, the work has to be done at a disadvantageous time, material that would otherwise be friable shall not be taken as hardpan or gumbo. — Hard pan Gumbo.

5th. All other excavation, except filling by train, of whatever kind, shall be termed earth excavation. — Earth.

6th. Train-filling.

The contract prices for the several classes of excavation shall be taken to include the cost of depositing the material in the embankment and all other expenses connected therewith, except extra haul, which will only be paid for where it exceeds 1,000 feet, at so much per yard per additional 100 feet. Extra haul shall not apply to train filling. — Over haul.

All excavations shall be neatly dressed with the required slopes as shall be directed by the engineer, and no rock excavation will be paid for beyond the limits of the base and slopes as specified or ordered. All rock loosened by explosives beyond the defined limits, must be removed at the expense of the contractor, but if required to make up the embankment, will be paid for as earth. — Dressing.

Rock filling must be substituted for the ordinary embankment over culverts and at other structures when and for such length as — Rock-fill.

the engineer may direct, if the rock therefor can be obtained within reasonable distance with or without extra haul.

Train fill. 105 On the order, or with the permission of the engineer, certain embankments may be reserved to be filled by train work, using a more or less substantial temporary trestle, as he may direct or permit, and the material shall be such, and brought from such locality and at such time, as the engineer may order or permit.

106 In cases where pitching or rip-rap will be required for the protection of embankments, or where rock-fill over culverts, or behind bridges, or in cribwork, will be required by the engineer, all stone suitable for this work, found in excavation, must be deposited in some convenient place until required, and all good building stone,

Stone. 107 which may happen to be found in rock excavation, may, with the

108 approval of the engineer, be preserved and used in masonry; but any material so found and used will not be paid for twice—the quantity will form a deduction from the quantity of the excavation as measured in the cut.

Fill at structures. 109 In forming embankments great care must be taken to place at the back of all walls, exposed to the action of the frost, rock-fill blinded with spalls or coarse gravel to prevent the retention of moisture and the action of frost thereon, the engineer to decide in each case the depth and thickness of such rock-fill; and in forming

110 embankments between wing-walls, against the abutments of bridges, viaducts or culverts and over arches, the earth-filling must be carefully packed or punned in thin layers, and a proper quantity of material must be placed equally against each side of and over all bridges, culverts and other work before the embank-

111 ment runs over it; and in forming embankments the greatest care must be observed, and every precaution must be taken, to load

112 the masonry of structures evenly. The price for excavation must be sufficient to cover the cost of punning. The loose stone back-

113 ing, above referred to, will be paid for as rock-fill.

Contractor's roads. 114 Road constructed to and from any points on the line of railway for the convenience of the contractor, for the conveying of the material or otherwise, must be at his own risk, cost and charges, but the Company will provide the necessary land for the right of way.

115 When slips occur in cuttings they must be immediately removed by the contractor, the slopes reformed, and such precaution

Slips. 116 adopted as the engineer may deem necessary. The contractor will be paid for the removal of slips at his schedule price.

Measurements. 117 The measurement of quantity shall be invariably made in excavation, unless in special cases where this may be found impossible. In such cases the engineer shall determine the quantities in embankments, after all proper allowance for shrinkage, of which he shall be the judge.

The prices stipulated for excavation of the several denominations, together with the price for haulage shall be the total price for excavation, loading, removing and depositing all material—in a word, the rates and prices stipulated in the contract must be understood to cover every contingency, the furnishing of all labour, material, power and plant, the cost of finishing up cuts and embankments, the dressing and draining of borrow pits when required, the dressing of slopes to the required angle, and the completion of everything connected with the grading of the road-bed in a creditable and workman-like manner, in accordance with the directions and approval of the engineer. 118 Prices final.

When the line is intersected by public or private roads the contractor shall keep open, at his own cost, convenient passing places and shall be held responsible for keeping all crossing and road diversions, during the progress of the works and thereafter in such condition as will enable the public to use them with perfect safety, and such as will give rise to no just ground of complaint. The contractor will be held liable for any damage resulting from negligence on his part , or on the part of his men. 119 Roadway preserved. 120

The approaches for road crossing shall be of such grades as the engineer may determine. 121 Approaches.

Road diversions shall be made in accordance with plans and surveys, or with the directions of the engineer. 122 Diversions.

ALL ROADS CROSSED.

On all roads, crossed by the railway on the level, a platform of hemlock or spruce shall be spiked down to the cross ties between the rails, and for a distance of eighteen inches on each side of the track. On private or farm roads the platform shall be twelve feet wide, made of three inch plank, and on public roads it shall be made of four inch plank, and twenty-four feet in width. The plank shall be spiked down with seven inch spikes in a secure manner, and all irregularities in the thickness of the plank shall be adzed off. 123 Crossing. 124 Platform. 125

In or under the earth work of the approaches culverts or drains shall be made according to the general designs, or special, if ordered by the engineer. The culverts shall be of sufficient length to pass through the approaches. The approaches, unless otherwise ordered, shall be made with a grade of not more than one in twenty. 126 Culverts in approaches. 127

PUBLIC ROAD CROSSINGS.

Public road crossings must be so constructed as not to impair the usefulness of the road, and the general drainage and flow of water must be restored to its original condition. The whole work must be executed so as to meet the approval of the engineer. 128

129 When the railway crosses public roads at rail level, cattle guards of cedar timber, with hard pine stringers (or surface cattle guards if ordered), shall be constructed.

Cattle Guards.

Under this heading shall be embraced every thing necessary to

Sign board and crossing complete.

130 complete the crossing: the cattle guards, planking, bridging of side ditches, fences from cattle guards to the line fences of the railway; also cedar post and pine sign board, finished, painted and lettered. The fences, connecting cattle guards with right of way fences, shall be of cedar posts and pine or spruce boards, all as per drawing.

Overhead bridges.

131 When public roadways are passed over the railway above rail level, overhead bridges shall be constructed, in accordance with drawing and special specification.

Farm crossings and gates.

132 Farm crossings shall be established wherever directed by the engineer. They shall be graded so as to form easy and convenient

133 passages for farm traffic across the rails. Gates with proper fastenings shall be placed in the fences, according to the drawing.

Overhead farm crossings.

134 When farm roads are passed over the railway above rail level over head bridges shall be constructed, in accordance with drawing and specification.

TUNNELS.

Stream tunnels.

135 The tunnelling will consist of "stream tunnels." The tunnels shall be driven through the solid rock, which, in some places, forms the sides of ravines. They shall be formed in the manner to be pointed out in each case. Open cuttings at the end shall be excavated to give an easy flow to the water. These open cuttings may be slightly curved, but the tunnels proper shall be perfectly straight from end to end, unless otherwise ordered by the engineer, with the sides as smooth as practicable. The up-stream end of each tunnel shall generally be one foot lower than the bed of the stream opposite, and the tunnels shall be driven with such inclination as the engineer may direct. Care shall be taken to leave a solid pillar of rock, between the tunnel and the side of the ravine, equal (except in special cases) to not less than double the width of the tunnel. The thickness of solid rock over the tunnel shall be similarly proportioned. The excavation in open cutting which forms the outlets of tunnels, shall be paid for as ordinary excavation, according to classification. The material excavated from them shall be placed in the embankments, or as may be directed by the engineer. The tunnels shall usually be oval in section. The tunnels shall be paid for by the lineal foot, and the price shall cover all the cost of pumping, draining, etc., which may be necessary.

136 The tunnels may be figured of the following dimensions:—

For lineal foot of tunnel equal 12 cubic yards.

do.	8	do.
do.	4	do.
do.	2	do.
do.	1	do.

If any concrete lining is required it will be ordered extra.

All road diversions, stream diversions and other works required, connected with excavation, shall be executed in accordance with plans and, or, instructions given therefor from time to time. 137 Diversions.

FOUNDATIONS.

Foundations for masonry or concrete structures shall be excavated to such depths as may be necessary to secure a solid bearing, of which the engineer shall be the judge. The material excavated shall be classified and paid for, as provided in these specifications, under the head of excavations; and, in the case of foundations in rock, the rock must be excavated to such depth and in such form as may be required by the engineer. 138 Foundation excavation. 139 140

When a safe and solid foundation cannot be found at a reasonable depth (to be judged of by the engineer), there will be prepared, by the contractor, such artificial foundation as the engineer may direct. 141 Artificial foundation

All materials taken from the foundation, if of proper quality, shall be deposited in the contiguous embankment; but any material unfit for such purpose shall be deposited outside the roadway, or in such place as the engineer may direct, and so that it will not interfere with any drain or water course. 142 Material, where deposited.

Timber foundations, when required, shall be such as the engineer may by drawings, or otherwise, prescribe, and will be paid for by board measure, the price covering cost of material, framing and putting in place, and of all wrought and cast iron ordered. 143 Timber foundation. 144

No masonry or concrete in foundations shall be commenced before the engineer shall have examined and approved the foundation, nor until the contractor shall have provided appliances and material of such kind and in such quantities as shall be approved by the engineer. 145 Foundation approved.

When a structure is to be founded upon rock the latter must be cleared from dirt, earth or other detrimental material to the satisfaction of the engineer, and, if deemed necessary, levelled, stepped or roughened to receive the concrete or masonry, and the contractor, if prices have been settled by contract, may be allowed to adopt any plan for his cofferdam that he may desire, provided he is able to lay the foundation dry, so as to properly prepare the rock to receive the masonry or concrete. 146 Rock-found preparation. 147

Bottomless caissons. 148 He will also be allowed, in building piers in water on rock, where the rock is considered suitable by the engineer, or where the bottom of the river forms a suitable foundation, to use suitable bottomless caissons, and the foundations shall be levelled off, or the timber at the base shall be shaped to allow for the irregularities of the surface.

Rip-rapped. 149 Structures on bottoms, liable to scour, must be immediately rip-rapped.

Caisson hour worked. 150 In bottomless caissons, where concrete is to be filled in under water, and there is, in the judgment of the engineer, any liability of the concrete washing, canvas shall be secured to the timbers and spread on the bottom, and bags of concrete shall be placed upon the canvas, and, where considered necessary by the engineer, these 151 bags shall be fitted by divers into the angles of the cribs and bottom, so as to prevent all scour.

Concrete placed unde water. 152 In cribs the proportionate depth of concrete deposited under water and that laid after the crib is unwatered shall be determined by the engineer. Caissons or cribs for this use shall be designed

Caisson design. 153 so that when de-watered they may resist the pressure of water due to the depth above the concrete that may be laid under water.

Borings. 154 For the purpose of testing important foundations, whenever required by the engineer, the contractor shall make soundings and borings with approved hydraulic or other approved boring outfit, or, if deemed necessary by the Government, with diamond drill, to such depths as the engineer may require, and said tests shall be made under the engineer's supervision.

Additional borings. 155 When caissons or cribs are sunk into the bed of the river or below it by dredging or otherwise, additional borings within the cribs may be required.

Testing concrete. 1 In important structures, where concrete has been deposited in caissons under water, if required by the Government, a diamond drill shall be used to obtain a core and determine the character of the concrete.

Space round masonry. 157 In caissons there shall be a space, at least two feet all round between the inner face of the timber and the masonry.

Batter. 158 If a crib is built with perpendicular sides the batter of the masonry produced must fall within the crib.

Special designs. 159 When special designs or plans for foundations are deemed necessary and supplied by the engineer, they shall be worked to.

160 Where piles are required they are to be driven with such weight

Piles. 161 of hammer and to such depth as the engineer may require; they are to be sawed off at a uniform level at such depth below water,

162 or otherwise, as the engineer may direct, and capped, if required, with twelve by twelve inch timber, with a twelve by twelve inch

163 platform to receive the masonry. All timber to be approved. In no case must any masonry be commenced till the foundation has

164 been approved by the engineer.

PILES, see timber work. 165

The soundings and borings, shown on plans exhibited by the engineer from time to time, are believed to be accurate, but should any errors be found hereafter, during the progress of the work, the Company will not be liable for any extras or claims on account of increased or diminished work. The Company will only pay the respective schedule rate for the amount of rock or earth excavation that may be necessary to prepare a suitable foundation, and for the amount of masonry or concrete therein. 166 Soundings Company does not guarantee.

STONE MASONRY.

First class masonry.

This masonry will be of the class known as rock-faced ashler, and must be first class in every respect. 167 1st class masonry.

The stone to be used in the abutments, piers, etc., must be approved by the engineer, and must be of the best quality and in every way suitable for the purpose for which it is to be used. It must be sound and durable, free from all drys, shakes or flaws of any kind whatever, and must be of such character as to withstand the actions of the weather, the water and the ice. No stones of an inferior quality will be accepted or even be permitted to remain upon the ground. 168

The beds of all stones for face work, and the backing where required to receive headers, must be dressed parallel throughout so as to form ⅝ inch joints, and the vertical joints of the face stones must be dressed back square for nine inches so as to form ⅝ inch joints. 169 Bed dressing.

The chamfers, arrises and cutwaters must be neatly chisel-dressed, as shown in the detail plans, and as directed during the progress of the work. 170 Chisel dressing.

The masonry in bridge abutments and piers must be of the best and largest stones that the quarry will afford. No course less than twelve inches in thickness will be allowed. The arrises must be chiseled two inches in width, and must be left perfectly true from top to bottom to the batter required. 171 Thickness of courses.

Headers must be built in every course not more than six feet apart, and so arranged with the adjoining courses as to leave them equally distributed over the faces of the structure. They must have a length in the faces of the work not less than twenty-four inches, and run back a depth of, at least, two and one half times their height unless the wall will not allow this proportion, in which case they must pass from front to back. In the abutments, where the headers do not pass through the wall, they must be built in from the back and front alternately. 172 Headers. Through stones.

Stretchers. 173 Stretchers must not be less than thirty inches nor more than one and one half times their height. The vertical joints must be so arranged that the stones overlap those in the course below at least nine inches for the twelve inch courses, with one inch additional lap for each three inches increased thickness of course.

Cut-waters. 174 The cutwater stones must be arranged as shown in detailed plans. The vertical joints must all be dressed back square for the

Iron clamps. 175 full depth of the stone. Iron clamps, of the required dimensions, with bolts passing through them down through one course and a half of masonry, must be let into the stones in the manner shown on the plans, and the holes filled in with neat cement.

Joints of backing. 176 The vertical joints of the backing will generally be left as they come from the quarry, unless they should be found of such a nature as to make the joints average more than two inches in width, in which case they must be hammered off so as to make the joint of

177 the required width. Care must be taken in arranging the backing

178 so as to afford proper ties for the headers and to get the stones as close together as possible.

Backing. 179 The backing, generally, must have an area of bed of, at least,

180 four superficial feet. In every case the beds under headers must make joints equal to the face work, and no pinning of any kind will be allowed under bottom beds. Where headers do not come the courses need not be levelled off, but may project into the courses above.

Face projection. 181 The work must be left with a clean quarry face, free from all rust or stain or marks of any kind, and in no case must the rock face project more than four inches beyond the line of pitching.

182 Every stone must be laid with a full bed of cement mortar and beaten solid. Spaces in the vertical joints, large enough to be built, must be built up, and all other vertical joints must be thoroughly grouted and each course finished off perfectly solid.

No hammering will be allowed on the wall after the course is set.

Hammering before set. 183 All the work must be carefully pointed with one to one cement mortar, and, at the completion of the contract, the work must be left in neat, clean and workman-like condition.

184 The girder beds and coping shall be according to plan, and shall be so arranged that the girders shall set fairly on the middle of the stones, with ¼ inch joints and 1 to 1 cement mortar.

Prices cover details. 185 It is understood that the prices for masonry, concrete, piles, caps and platform put on the schedule is to cover the cost of all materials, plant and workmanship necessary for the construction of the cofferdams or caissons, and all pumping or bailing, and any other work required to found the piers, abutments, etc., in a sound and substantial manner, and that no extra price will be paid for

any extra work that may be required to secure this object. The profiles of the bottom of the river crossings will be prepared from soundings, but the Company will not be responsible for their accuracy. The contractor must satisfy himself on this point, and it is to be fully understood that no claims for extras will be permitted on account of any inaccuracy in the plans, and the contractor shall have no claims for extras on account of any increased or diminished quantities of masonry in any piers or abutments, or on account of any increased or diminished depth of water on the site of any of the piers or abutments. He shall only be paid for the actual quantities at the schedule rates.

Increase or decrease.

SECOND CLASS MASONRY.

This masonry shall be similar, in all respects, to first class masonry except that broken courses will be allowed, with ½ inch joints, and that stones eight inches in thickness may be used. The stones used must have an area of beds of similar proportion to that specified for first class stones, based on an assumed minimum thickness of twelve inches. That is, stretches must have a minimum width of eighteen inches and headers a minimum depth of thirty inches. Headers may be eighteen inches in width and form ¼ the face. 186 2nd class. 187 188

The chamfers, arrises and cutwaters will be pitched off to line and left perfectly true from top to bottom, to the batter required. The girder beds shall not be less than twelve inches thick for the smallest bridges and eight feet area on bed. The larger bridges will require bed stones of proportionally greater weight. These must be solidly and carefully placed in position so that the stringer or girder will set fairly on the middle of the stone, and the top of the stones shall be dressed off perfectly true and level. 189 Pitching. 190 Girder beds.

Arches of ten feet span and upward, when built in masonry, must be constructed of stone, so that when laid their beds will radiate truly from the centre of the arch. The depths of stone must, of course, vary with the spans, but never exceed 27 inches. They must not be less in length than 27 inches. Their thickness on the soffit must be, at least, 9 inches. Each stone must be well embedded in cement mortar and grouted when necessary. 191 Arches 10' and up.

Arches under 10 feet span, when built in masonry, shall be constructed of suitable flat bedded stones ranging, according to the span, from 16 to 24 inches in depth and from 5 to 6 inches in thickness on soffit. They must invariably extend through the whole thickness of the arch. Each stone must be well and closely fitted so as to give close joints and break joints with its fellow 7 or 8 inches. The whole must be laid in cement mortar and grouted where necessary. 192 Arches under 10'.

Arches flushed and rounded. 193 All arches must be built in cement, and, before being covered with earth, or the centering removed, they must be thoroughly flushed on the back, rounded up and brought to a smooth surface.

CULVERTS IN CEMENT.

Culvert. 194 Masonry of this class must be used in box culverts and small beams.

Masonry. 195 The stone to be used must be good and sound, laid on its natural bed, and must not have a thickness less than 10 inches and an area of bed of not less than three superficial feet.

Joints. 196 The courses may be broken. Joints must be hammer dressed or pointed down so as to make them not more than ¾ inch in thickness.

Headers. 197 Headers must be built in every course not more than 6 feet apart, and in the side walls must run through the walls from front to back.

Stretchers. 198 Stretchers must have a depth in the wall of one and one half times the thickness.

Backing. 199 The backing must be built of good large flat bedded stone well tied into the face stone, and thoroughly flushed up full and solid with mortar.

Mortar. 200 The mortar must be made of cement, approved by the engineer, in the proportion of one of cement to three of good, clear, sharp, coarse grained sand.

Broken stone The foundations must be on broken stone, or as directed by the engineer.

Foundation. 202 Box culverts may also be laid dry. In this case the stones must be of superior class, approved by the engineer as suitable for this work. The stones in the side walls must all be dressed to half inch joints. The top course under the covers must all be through stones. No course must be less than 12 inches in thickness unless permitted by the engineer.

Dry masonry.

Concrete backing. 203 Concrete backing may be used where directed or shown on drawings.

MORTAR.

204 All masonry, where required, shall be laid in cement mortar, and cement must be thoroughly mixed with good, clean, sharp, coarse grained river or washed sand, generally in proportion of one

Mortar general. 205 part of cement to two parts of sand by measure. The cutwater stones and copings shall be laid with mortar in proportions of one part of cement and one of sand.

Satisfaction required. 206 The mortar shall only be mixed as required. Any cement mortar left over at noon or night shall not be used, and it must be prepared

by the contractor's men under the supervision and to the satisfaction of the inspector. Failing which, the inspector, with the sanction of the engineer, may employ men to prepare the mortar, and the expense incurred shall be charged to the contractor and deducted from his estimate. 207 On largest bed and saturated.

All stones must be laid on their largest natural bed, and must be saturated with water when they come in contact with mortar.

PAVING.

The bottom of the culverts to be paved with stones set on edge to a moderately even face, and packed solid. The paving must be from 9 to 16 inches deep. 8 Paving.

When ordered, it must be grouted.

DRY STONE DRAINS.

Dry stone drains will be constructed by digging a trench to the required depth and filling it with stone laid so as to permit free passage of water. 209 Ton drains.

RIP-RAP HAND LAID.

Embankments, at such points as may be designated, will be protected with hand laid rip-rap, which is to be of such thickness and laid in such a manner as may be required by the engineer. 210 Rip-rap hand laid

RIP-RAP, ORDINARY STONE FILLING.

Such piers as the engineer may direct, are to be surrounded with ordinary rip rap or stone filling to such a height and width as he may consider necessary. The same class of rip rap will be used behind walls of abutments and elsewhere, when required by the engineer. 211 Rip-rap ordinary.

CULVERT PIPE.

Drain pipe may be substituted for culverts when so ordered by the engineer. Sizes of twelve (12), fifteen (15), eighteen (18) or twenty-four (24) inches diameter may be used, and the quality must be the best double strength vitrified pipe, subject to the approval of the engineer. Drain pipes must be well and carefully bedded and laid, and in accordance with the instructions of the engineer. Cast pipe, 20 to 48 inches diameter, may also be used for culverts when so ordered by the engineer, who may require masonry intakes with paving for all of the same if found necessary. 213 Culvert pipe. 214 215 216

RETAINING WALLS.

Retaining walls. 217 Retaining walls will be classified as *second* or *third* class masonry, laid dry, as may be ordered in each particular case.

Side hill. 218 All side hill ground that is wet, or spongy, or likely to be affected by water, must be thoroughly under-drained, so that no water will lodge between the new bank and the old ground. The drains

Under drains. 219 are to be put in as directed by the engineer. Trenches will be cut longitudinally and transversely to a depth of about four (4) feet and an average of eighteen (18) inches in width. In the bottom of these trenches tiles of such dimensions as the case may require,

220 or from three (3) to six (6) poles averaging about five (5) inches in diameter, will be laid, breaking joint. These are to be covered with brush or sods and then filled in with earth taken out of the

221 excavation. Similar drains to these are to be put in wet cuttings where directed by the engineer. They will be paid for at so much per lineal foot, including excavation and filling, the contractor to find all the materials for the same.

222 The covering stones of all box culverts shall be of the thickness shown—never less than 10 inches in thickness—and must have

Culvert covers. 223 a full, solid and well-levelled bearing on the side walls of not less than fifteen (15) inches.

Brick. 224 Brick masonry must be laid with the best quality of hard burned brick, well tempered and moulded to standard size. No bats, cracked, crooked or salmon bricks, under any circumstances, will be allowed in the work. The bricks shall be well soaked in water before being laid, and shall be laid in the best hydraulic cement mortar, with such thickness of joint and style of bond as shall be prescribed by the engineer. Grout will be substituted for

Arch. 225 mortar when ordered by, and to such extent as may be desired by, the engineer. Brick arching must be coated on the back with a

226 coating of strong cement mortar one (1) inch in thickness, and, in tunnel arching, wherever a seam of water is met, the arch must be covered over with roofing felt or a course of asphaltum applied hot, of such thickness as may be directed by the engineer, and this covered again with a plastering of cement mortar, so as to make

227 the arch impervious to water, a drainage channel, properly formed, being made for it in the backing of the arch and side walls, with

228 suitable openings left for its escape at such points and of such size as may be directed by the engineer. The "keying" of all arches shall be most carefully done in such manner as may, from time to time, be directed by the engineer. The "packing" between the arch and tunnel roof, over any section of the arch, shall never be done until the section has had at least forty-eight (48) hours for setting after being "keyed."

Brick substituted. 229 Brick masonry may, at all times, be substituted for stone where so directed by the engineer.

230 Concrete. Concrete composed of broken stone, gravel and Portland cement mortar, varying in proportions according to requirements, set in trenches, temporary moulds or permanent timber casing, will be used when and where ordered by the engineer.

231 Notice when ready. Notice of readiness to mix concrete for any structure must be given the engineer, at least, three days before beginning the operation, in default of which the contractor will be required to remove the same forthwith.

232 Concrete in water. Concrete to be set in water shall generally be that designated below as concrete No. 1. It shall be deposited in approved paper bags prepared with glucose, or in or through other appliance approved by the engineer.

233 Special care must be taken in depositing it so that it will not fall for any distance through the water, and, in any case, it must be protected from moving water till properly set.

234 Twisted iron. Twisted square iron or steel bars, imbedded in the concrete, may be required as described below.

235 Damage concrete. Any damaged concretes, whether in foundations or above, must be removed from the structure at the earliest possible time, and before any fresh concrete is deposited.

236 Concrete in the day. Concrete set in the dry in trenches and foundations and in the hearting of culvert walls will generally be that designated below as concrete No. 2.

237 Precautions. The sides of excavations therefor shall be carefully protected so as to prevent loose earth, or other material, from falling into or damaging the work or foundation, and foundations thus constructed must be kept perfectly clear of water.

238 Pier concrete. Concrete, when ordered in bridge abutments and piers and other important structures about foundations, will be generally concrete designated as concrete No. 3 faced on all exposed sides and on top with a facing mortar No. 5, or built as may be prescribed on the special drawing supplied by the engineer.

239 Facing. The facing to be, at least, four inches thick, deposited at the same time with the hearting, kept three inches above the hearting while they are being deposited, and the two thoroughly incorporated so that they form a monolith and no joints or cleavage can appear between them, the hearting being deposited in layers of not

240 Hearting. over 12 inches in depth, and the whole rammed in place with steel chisel-pointed rammers of not less than 20 lbs. in weight.

241 Rounded corners. When practicable the corners of cement work are to be rounded off to a radius of one foot.

242 Cavities. Any holes and cavities in the work are to run up full and flush with Portland cement grout consisting of two parts sand and one cement.

Temporary cessation. 243 Whenever work is discontinued for the time, the surface is to be left rough, and is to be left thoroughly protected from water in motion; and when work is resumed the surface must be thoroughly cleansed from all mud, slime or impoverished concrete, and a fresh layer of fine concrete first spread.

Top facing under bridge seat etc. 244 The facing on top of piers, abutments and other structures must be put on and finished off smooth and level or true as soon as possible, not more than 12 hours later than the last layer was put on.

Mixing. 245 In mixing concrete, if by hand, the sand and cement must be thoroughly mixed dry, then spread over gravel and broken stone which have been previously saturated with water, and the whole turned at least three times. Water is then to be sprinkled on, in quantity to the approval of the engineer (about 20 gallons per cask

246 of cement used, while the materials are being turned over again three times and before being placed in the works. If mixed by approved mixing machine the whole operation shall be entirely subject to the approval of the engineer.

Protected. 247 Concrete set above ground to be protected from sun and wind and kept wet until hardened.

Immediate use. Satisfaction. 248 All concrete to be placed in the work at the same time as made, and any concrete not so placed will be rejected.

All concrete must be prepared by the contractor's men working under a competent concrete foreman, and under the supervision and to the satisfaction of the engineer's inspector. Failing which, the inspector, with the sanction of the engineer, may employ men to prepare the concrete, and the expense incurred shall be charged to the contractor and deducted from his estimate.

The concretes specified for are:—

249 No. 1 Portland cement concrete for use under water.

Proportioned.

1 cask Portland cement (375 lbs. net),

1½ casks sand, loose.

1 cask small gravel or broken stone (of approved size and quality), not over one half inch in diameter.

3 casks stone broken to 2 inch cubes.

No. 2. 250 No. 2 Portland cement concrete for use in the dry foundations, etc.,

Proportioned,

1 cask cement packed (375 lbs. net),

3 casks sand, loose,

3 casks fine gravel,

6 casks broken stone, or 7 casks broken stone mixed.

No. 3. 251 No. 3 Portland cement concrete for use in the dry for more important works.

Proportioned,
1 cask Portland cement (375 lbs. net),
3 casks sand, loose,
1 cask fine gravel or broken stone,
4 casks hard stone broken to two inch cubes.

Rubbel concrete must be made, when directed, by using either of the above concretes as a matrix into which large stones weighing 40 lbs. and upwards, are to e placed by hand. The quality and dimensions of the stones must be in accordance with the directions of the engineer or his officer in charge, in proportion of not over four parts. In construction the matrix is first placed in the work and a layer of the same formed. The large stones spaced not less than six inches apart, nor nearer the outside than one foot, must be carefully embedded in the concrete when soft, and shall be dropped from a derrick on their widest bed if so directed. Each two foot course of rubbel concrete must be levelled roughly throughout before another course is begun, run up solid with the matrix and rammed so as to form a compact mass; and any holes or cavaties in the work are to be run up full with Portland cement compo consisting of two parts of sand and one of cement. 252 Rubbel concrete. 253 254

These rubbled concretes may be designated as rubbel concrete No. 1, No. 2 and No. 3 respectively, according to the matrix used. 255 No. 2 & 3.

No. 5 concrete facing.
1 cask Portland cement, 256 No. 5.
2 casks sand.

If concrete culvert covers are ordered, they will be made under cover, according to special instructions, and probably have twisted square iron or steel embedded therein, and will be made generally of concrete No. 1. 257 Co. crete culvert.

Arches, also, will be under special instructions, and generally of concrete No. 1. 258 Covers.

Best iron or mild steel bars, from a quarter inch to one inch square, and of convenient lengths, twisted as directed, may be used to strengthen the concrete where deemed necessary by the engineer. All bars to be grouted round with extra one to one and one half Portland cement mortar, when required, and to the satisfaction of the engineer. 259 Twisted iron or s eel. 260

The sand shall be coarse grain or mixed, of silicious material, free from soft grains, and cleansed to the satisfaction of the engineeer. 261 Sand.

The gravel shall be of hard material, free from anything shaley or frayable, and washed free from mud, slime or vegetable matter, and approved sizes, all to the satisfaction of the engineer. 262 Gravel.

The broken stone shall be of hard material, free from free-stone or anything shaley or frayable, or any mud, slime or vegetable 263 Broken stone.

matter, broken to approved sizes and screened. The fine part may, with the consent of the engineer, be taken as sand, and the small stone as gravel, and care must be taken to have the bulk of it in as near two inch cubes as possible; and all to the satisfaction of the engineer.

PORTLAND CEMENT.

Portland cement.

All cement furnished for the work will be subject to inspection and rigorous test, and, if found of improper quality, must be immediately removed from the works.

Tests.

It must comply with the following tests:

Fineness.

The cement must be ground to a degree of fineness so that 90 per cent. will pass through a seive of 10,000 meshes standard to the square inch and 70 per cent. through a seive of 40,000 meshes to the square inch.

Pats

Hot water.

Pats shall have a blue grey colour free from yellow spots and blothes. Under hot water or steam test they shall show no sign of swelling, blowing or cracking.

Chemical.

When a portion of the sample is dissolved in hydrochloric acid it must not fail to form a perfect, though not necessarily a clear, solution; and, in the judgment of the engineer, no considerable effervescence of carbonic acid gas shall take place, and no undue precipitate shall appear. On the solution being filtered and boiled, and a small quantity of barium chloride being added, no greater amount of precipitate shall be formed than an allowable limit of one and one half per cent. of the sample operated on.

The tensile strength in briquettes of neat cement shall be:—

One day in air and six days in water, 450 lbs. per square inch.

One day in air and twenty-seven days in water, 600 lbs. per square inch.

The tensile strength in briquettes of one part of cement in three parts of sand by weight, shall be:—

One day in air and six days in water, 150 lbs. per square inch.

One day in air and twenty-seven days in water, 250 lbs. per square inch.

The sand used in briquettes will pass through a seive 20 meshes to the lineal inch and be retained upon one of twenty-eight meshes.

In casks.

The cement must be put up in well made casks so as to be reasonably secured from the air. When stored it shall be kept in a tight building free from draughts, and each cask must be raised several inches from the ground, by blocking or otherwise, so as not to be liable to absorb moisture.

On hand for test.

Cement must be on hand long enough before use to allow of required test.

It must be put up in well-made casks, etc., as above.

Instead of the test above, after the first paragraph, the following may be substituted:—

The character and severity of the tests to be determined by the Government engineer and to the satisfaction of the engineer.

All masonry or concrete work and other structures shall be made in accordance with the plans and, or directions given therefor by the engineer from time to time. According to plans.

TIMBER WORK.

The timber used in all truss, trestle or pile bridges, culverts or cattle guards must be of the very best description of the kind required, free from all loose, large or unsound knots, sap, sun cracks, shakes or other imperfections. When so required it must be sawed or hewed dye square and out of wind, and when delivered must in every way conform to the specification. 278 Description of material.

The permanent stringers and guard rails, when of wood, must be of the best class of southern hard pine, or such other timber as may be approved by the engineer, and must, in addition to the requirements above mentioned, be free from all sap, knots, wanes or anything else that would impair their transverse strength. 279 Stringers.

Special ties of southern hard pine are to be used where required over all stringers. 280 Ties or stringers.

Inspection will be made when delivered on the Company's ground, or other place, pointed out by the engineer. 281 Delivery.

The Company retains the right at any time to change the bills of timber, vary the dimensions, substitute one kind of structure for another or increase the number of the same without the contract price being thereby affected, or rendering void in any way the contract for the original figures. 282 Right to alter.

In delivering timber it must be piled or placed in such a manner that no trouble will be experienced when inspecting or measuring it. 283 Delivering in piles

The timber for trestles must be of good sound material approved by the engineer. The timber for permanent trestles above the piles or mud sill foundations to be of southern hard pine. Mud sills to be of cedar or hackmatack. 284 Material in trestles.

The timber for cattle guards or culverts, excepting stringers or ties, will be of cedar. 285 Cedar.

All timber must come fully up to the dimensions called for on the bills and drawings. 286 Dimensions.

Iron, rock-elm or hackmatack pins of such dimensions, of such shape, and of such numbers as deemed necessary by the engineer shall be used in pinning, in a proper manner, the timber in all culverts and cattle guards. 287 Bolts or pins.

Framing. 289 All framing must be made to fit closely and must be done in a thorough and workman-like manner. No open joints or filling pieces will be allowed.

Mortices. 290 Mortices and tenons will be well and truly made, and the entire structure shall conform in every respect to the drawing provided.

Each structure must be under the supervision of a first-class,
291 practicable, bridge foreman.

The price per lineal foot or per cubic foot, or per 1,000 feet board
Price general. 292 measure, is understood to cover all expenses incurred in completing the structure to the satisfaction of the engineer, including all iron or other material required.

Piles will consist of hard pine, hackmatack or other timber ap-
Piles. 293 proved by the engineer, and, in special cases, may be required to be creosoted. They must be straight and sound throughout, and not less than 9 inches in diameter at the small end, not including the bark, and shall square 12 inches at the butt. When required, a detailed plan will be furnished by the engineer, showing their position and method of tenoning, bolting, etc., and they shall be driven to
294 such a limit of resistance as the engineer shall determine. The
Resistance required. 295 contractor must properly appoint each pile for driving, and supply and fix all rings for heads, also shoes, where necessary.

Should the nature of the ground or other causes reduce the
Exceptional cases. 296 sinking of the piles to the limit of resistance directed, before sufficient distance has been penetrated to ensure (in the Engineer's opinion) the stability of the structure, the contractor will be required to continue driving, without additional charge, until such depth has been reached as may satisfy the engineer.

Should any pile be broken in driving, another sound pile must
Broken joints. 297 be driven in its place at the expense of the contractor. During the progress of the driving wrought iron bands must be supplied by the
298 contractor. The necessary lengths of piles shall be ascertained by driving test piles in different parts of the localities in which they
Lengthening piles. 299 are to be used; and, in case a pile shall not be long enough to reach "hard bottom," it shall be sawed off square, a hole 2 inches in diameter be bored into the head 12 inches deep. Into this hole a circular white-oak tree nail, 23 inches long, shall be well driven, and another pile, similarly squared off and bored, and of as large a diameter at the small end as can be procured, shall be placed upon the lower pile, brought to its proper position, and driven as before directed.

The piles to be paid for, in foundations, at so much per lineal
300 foot measured in the finished structures, which will include all work in connection therewith, including cutting off, squaring and
301 lining up, etc. In pile bridging the work will be paid for at so much per lineal foot of bridge complete ready for the rails.

All pile bridging to be as shown on plans furnished, workmanship to be first class, quality of timber to be as above specified. 302 How paid for.

All wrought iron used in the construction of the bridges, trestles or other work or foundations, to be of the very best quality, to stand a tensile strain of fifty-five thousand pounds per square inch, and to stand bending over around its own diameter without showing signs of any flaw or crack. 303 Wrought iron.

All castings to be made of best grey iron, and, when finished, to show a clean smooth surface free from holes, cinders or other imperfections. 304 Cast iron.

Cribs of round logs, not less than 9 inches in diameter at the small end, filled with approved stone, on a ballast floor of 6 inch poles, will be built, where ordered, for the protection of embankments, in accordance with plans. Where the bottom is soft, brush and poles, two feet thick, will be placed underneath. The logs to be of sound cedar, or other material, approved by the engineer. 305 Crib protection. 306

Timber culverts, in banks up to 12 feet, and timber cattle guards will, when ordered, be built of sound cedar 10 feet by 10 feet, with hard pine stringers and cross ties when required, and in accordance with plans to be furnished by the engineer. 307 Timber culverts.

Note.—Surface cattle guards, of description to be hereafter determined, may, when ordered, be substituted for the timber ones above mentioned. 308 Surface cattle guards.

Pile bridges, trestles, wooden truss bridges, wharfing and any other timber structures required, when ordered, must be constructed in accordance with plans and detailed instructions to be furnished by the engineer. 309 General.

PAINTING AND JOINT FILLING.

Any piles of timber required to be creosoted shall be of southern pine, or other wood ordered, of the best quality, sound and green, straight and free from shakes and knots. It must be thoroughly seasoned at a temperature between 212 and 230 degrees Fah., and all the air and moisture must be exhausted in a vacuum of 24 inches, and in that condition it must receive the creosote. Each cubic foot creosoted must contain not less than 10 lbs. of heavy creosote oil, which shall be forced into the timber under a pressure of not less than 150 lbs. per square inch. 310 311 312 Creosoting.

The creosoting shall be done in the most approved manner, and to the satisfaction of the engineer or inspector, who shall have full power to reject any creosote or timber, whether before or after treatment. 313

Creosote oil shall contain not less than twenty-five per cent. of tar acids and not less than twenty-five per cent. of ingredients that do not distil over at a temperature of 600 degrees Fah. It 314 Creosote oil.

shall generally be solid at a temperature of 50 degrees Fah., and entirely liquid at a temperature of 100 degrees Fah. It shall be free from water, ammonia, naphtha and any other impurities.

CAMPS AND OFFICES.

Camps and offices. 315 The contractor shall supply suitable and comfortable camps and offices for the engineering staff when and at such places as the engineer may direct, and to his entire satisfaction.

TELEGRAPH AND TELEPHONE.

Telegraph and telephone 316 The contractor shall erect, and, during the continuance of the contract, maintain for the Company's use, during construction and thereafter, a telegraph or telephone line along the Company's right of way with connections to the Company's offices, complete with instruments as and when ordered by the engineer, and shall deliver them at the expiration of the contract in perfect working order.

The line will, probably, be used as a telephone line during construction and the telegraph line installed thereafter.

The main line shall be built in a substantial manner, as follows:—

Cedar poles, thirty-five to the mile, shall be provided, 35 feet long, not less thn 5 inches free of bark at the small end, free from defects, and shall be sunk in the ground not less than 5 feet.

Glass insulators on painted American oak pins 46" x 15" per th. Painted Am. oak brackets 19" per th

The poles shall each be provided with one or more brackets or a two-wire cross arm, with glass insulators complete, as may hereafter be ordered by the engineer.

The brackets to be of the best quality, painted, and securely attached with two spikes each.

The painted cross arms, of approved size and material, to be securely bolted to the poles with two loge screws each.

For temporary connection to the Company's or contractor's offices, poles and fixtures of size and material approved by the engineer may be used.

or No. 8 B.W. G. Gal. iron tel. wire British P. O.D. spec "

The telegraph wire shall be No. 9 iron wire galvanized.

The poles to be erected soon after the clearing is completed on the various sections of the line.

Steel bridging etc. 317 All steel girders, trestles, truss bridges and other structural steel or iron works, ordered by the engineer, shall be constructed, erected, completed and then tested in accordance with plans and specifications approved by the engineer, and with the specification of the Department of Railways and Canals of Canada, A.D. 1899, wherever applicable thereto.

Rails. 318 The Company has contracted for all or most of the rails required for the line, and the contractor shall take over this contract and

supply all rail joint bars, bolts, spikes and other permanent way supplies, ordered by the engineer, at such points accessible to the railway as may be designated; and the contractor will be required, at his own cost and expense, to provide all labour, space and appliances for handling them at the place of delivery, and for sub-delivery from these points to the line. 319

The rail will be the Pennsylvania Steel Company's section No. 202 weighing 80 lbs. per yard. 320 Pattern.

The joint bars and bolts will be their standard joint section 1202 unless otherwise ordered by the engineer. 321 Joints.

The spikes shall be made from the best refined iron or mild steel ⅝ of an inch square, and shall, on test, be equal to being bent to a double without fracture; and they shall have pressed heads of approved size and form and points chisel sharpened. 322 Spikes.

They shall be six inches long over all and similar to sample, to be approved by the engineer. All other permanent way supplies shall be according to pattern or sample approved by the engineer. 323

All culverts, bridges and iron trestle work will be inspected by the engineer. 324 Inspector.

The bridges and trestle work to be inspected thus:—

Two or more engines, of at least 50 tons weight each, tender and engine, provided by the contractor, to be placed in full working order, with necessary drivers and attendants, under the control of the engineer. The two engines and tenders will be coupled together and made to run at high speed of, say, 35 miles per hour over the structure being tested. Next, they will be required to run with good speed and the brakes applied at once, so as to stop the engines on the centre of structure, or on any one point of structure which they may be required to stop upon. And they shall be at the service and command of the inspecting engineer to make such other test as he may deem desirable to ascertain the deflection, vibration or permanent set which the structure may undergo during such tests, and its capability to give the desirable factor of safety. 325

The contractor is to give the engineer ten days notice in writing, stating the time and place at which the two engines mentioned will be ready for the inspection. 326 Notice.

CROSS TIES.—TIMBER SIZE.

Cross ties will be accepted of cedar, hackmatack, white pine, hemlock or black spruce, as the engineer may direct, and must be eight (8) feet in length, seven (7) inches in thickness, and not less than six (6) inch width of face on both sides at any point, and there must be, at least, one-fourth of the number that will be not less than eight (8) inches in width of face. 327 Material 328 Size.

MANUFACTURE.

Quality. 329 All ties must be made from sound, thrifty, live or green timber, free from loose or rotten knots, worn holes, dry rot, wind shakes, splits or any other imperfections affecting the strength or durability of the timber.

Make. 330 Not more than one (1) inch of sap-wood will be allowed on the edges or corners of the ties. They must be hewed or sawed with the faces true and parallel, of the thickness specified. The faces must be out of wind, smooth and free from any inequalities of suface, deep score marks or splinters. They must be cut or sawed square on the ends to the length given, and be generally straight in all directions, and will not be accepted of more than three (3) inches out of straight in any direction, and must be peeled or stripped entirely free from bark before being delivered.

Culls. 331 No "square ties," either hewed or sawed, will be accepted except for switches, no split ties will be accepted under any circum-
332 stances, and "culls" only at the option of the engineer, for use in sidings only.

SWITCH TIES.

Switch ties. 333 Long ties will be required for all switches, of dimensions, lengths and kind of timber to be directed by the engineer.

DELIVERY.

Stacked. 334 All ties delivered along the line of railway must be stacked up in neat square stacks of fifty (50) ties in each, with alternate layers crossing each other, and on ground, wherever possible, as high or higher than the grade of the railroad, and in such position as to admit of being counted and inspected with ease and facility. Ties delivered at suitable and convenient places, acceptable to the chief engineer, will be inspected and accepted up to the last day of each month and included in monthly estimates.

335 The track materials, consisting of the rails, cross-ties, switch timbers, spikes, splice bars, frogs and switches and their appurtenances, timber and plank for cattle guards and road crossings and
Delivery. spikes, etc., for the same, shall be delivered at convenient points accessible by railroads, river or canal, as the engineer may designate (excepting where materials may have been already delivered before making contract). After being so delivered they will be considered as being in the contractor's custody, and he will be held responsible for their safe keeping.

The contractor will be required, at his own cost and expense, to provide all labour and appliances required for handling and sub-delivery from these points. 336 Sub-delivery.

The track shall be accurately laid to the line and level stakes given by the engineer. 337 Track stakes

Before a tie is laid, and just before the track laying is begun, a small gang of experienced graders will go ahead of the tie layrs, with an engineer who will give grades and the super-elevation of curves. 338

The graders, in charge of a competent foreman, must be provided with the necessary sight-boards and other tools and implements required, and will carefully level off the surface of the road bed to the grade stakes set for same, and no indifferent levelling of grading will be allowed. 339 Trimming.

Cross ties must number not less than 2,816 to the mile of single track. They must be uniformly spaced between the rail joints, except the joint ties, which must be spaced in conformity with the drawing of standard track. They must be laid truly at right angles to the rails on straight lines, with their outer ends laid to a true line parallel with and four feet distant from centre line of track for eight foot cross ties. 340 Cross ties. 341 Laying.

The three joint ties must be as near as possible to the sizes given, and must be spaced as shown on standard joint diagram. 342 Joint ties.

Cross ties must not be notched, but, if necessary, must be adzed down to give a true and uniform bearing for the rail. The ties must not be laid further in advance of the rails than may be, from time to time, directed by the engineer in charge, according to circumstances, and the spaces for joint ties must be carefully measured and staked off. 343 344

Switch ties and frog timbers must be laid in accordance with the standard drawings for same. 345

Ties on curves must be laid on truly radial lines, and their northern ends accurately lined up to curves parallel with track. 346

No blocking up under cross ties, with timber or unbroken rock, will be allowed. 347 No blocking.

MANIPULATION OF RAILS.

The rails, if bent in handling, must be carefully straightened before being laid in track. And every rail used on curves must be curved, in a bending machine, accurately and truly to ordinates, which will be furnished by the assistant engineer in charge. And in no case will forcing, springing or sledging the rails be allowed. 348 349 Bending.

The rails must be, invariably, laid with the maker's brand letters always on the outside of the track. 350 Maker's name.

This rule must be strictly carried out. 351

Guage. 352 The gauge of track will be four feet eight and a half (4′ 8½″) inches on straight lines, and on curves the standard for "wide gauging" will be one sixteenth inch per degree of curvature.

353 This increase of gauge must be accompanied by the corresponding super-elevation of the outer rail.

Super-elevation. 354 This super-elevation of the outer rail on curves, unless otherwise ordered, will be 0.05 per degree of curvature.

TRANSITION CURVES.

355 The super-elevation must correspond with the curvature.

Transition curves. 356 All curves of over 3 degrees of curvature per 100 feet will have transition curves properly laid out at each end, and, except in special cases where it may be differently ordered, the curvature shall vary by 1 degree for each thirty feet till the maximum in each case it attained, and the rails shall be bent to correspond to the nearest degree of curvature in accordance with their location. Where there is no easing of curvature the super-elevation shall taper out on the tangent, at least 30 feet for each degree of curvature.

Spikes. 357 There must be four (4) spikes to each cross tie, two (2) inside and two (2) outside of the rails, driven with a proper amount of "stagger" so as to avoid splitting the cross-tie, and the two (2) inside spikes to be driven in the same edge of ties so as to keep the ties at 358 right angles to the track. On sharper curves than four (4) degrees an additional spike will be put on outside of outer rail. Spikes must always be driven where there are slots in the splice bars except in bridges. In cold weather place the spikes against the edge of the slots nearest the end of the rail; in hot weather against the other side of the slot.

359 In driving spikes on the gauge side care must be taken to place 360 the gauge at right angles with the rail. The spikes must be driven as nearly perpendicular as possible, and not more than four inches from centre to centre of spike on a line parallel with rail, and no blow must be struck after the hook of the spike is fairly down on 361 the rail flange. Great care must be taken not to strike the rail, and none but experienced and expert spikers must be employed on the work.

Breaking joint. 362 The rails will be laid to break joints, and great care must be taken not to let the joints run ahead, but to keep them always exactly opposite the centre of the opposite rail. Not more than one foot variation in this particular will be allowed.

Expansion allowance. 363 Expansion and contraction of rails will be provided for by the use of the following rule for various degrees of temperature:—

Open joints for 80 Fahrenheit one sixteenth of an inch.

Open joints for 70 Fahrenheit one eighth of an inch,

Open joints for 60 Fahrenheit three sixteenths of an inch.

Open joints for 50 Fahrenheit one fourth of an inch.

Open joints for 40 Fahrenheit five sixteenths of an inch.

Open joints for 30 Fahrenheit three eighths of an inch.

364 Iron shims. The use of iron shims, for securing the spacing, will be imperatively insisted upon, and the contractor must provide himself with a sufficient quantity of them of the thickness above specified.

365 Joints at openings. Joints on or within four feet of cattle guards or open culverts, or in road crossings must be avoided wherever possible.

366 Gridiron. If gridiron frames are used they shall be placed in position by the track layer, to whom standard plans will be furnished.

367 Crossings. Road and farm crossings must be put in, wherever required, in full accordance with the standard drawings. The plank will be placed two and one half (2½) inches from the gauge side of rails. The ends and edges of plank nearest to rail must be bevelled. Crossing plank must not be fully spiked down before the track is ballasted and relined and surfaced. The use of track spikes for securing crossing plank is strictly prohibited.

368 Joint bars. In putting on the splice bars great care must be taken to get them in exact position with the holes properly matched and the bolts screwed up.

369 Side track. Side tracks and switches must be as carefully laid as any other portion of the work.

370 Guard rails Safety guards may be applied, at the approaches of all bridges, with connecting guard rails, for which a set of general standard plans will be furnished.

371 " Rail guards, when used in connection with switches, must be of proper length, slightly bent at ends, and properly adjusted and securely fastened.

372 Switches. Plans will be furnished of standard switch stands, frogs and fixtures, showing minor details of placing in position, which must be conformed to.

373 Track lined and tamped Before any construction car or engine is allowed to run over the rails the track must be lined and ties must be firmly tamped to a good level so that there shall be no chance of straining or bending the rails.

374 No disfiguration. Material for tamping must not be dug out of embankment and bermes, nor shall any material be taken from the side slopes of cuts in such way as to disfigure them.

375 Track kept up. When track material is being hauled by contractor's trains over track already laid, such track shall be kept in good line and surface by the contractor.

376 Track laying. The contractor will be required to lay and finish the track at any accessible point where there may be a continuous stretch of completed road bed of not less than five (5) miles of track ready to receive it, on being notified by the chief engineer to do so.

Plant distribution track ballast etc.

377 The work of track laying and ballasting will embrace all engines, cars and plant, and all labour and tools required for loading, unloading and distributing rails, joint fastenings, spikes, points and crossings and sleepers or cross ties, laying, lifting, centering, lining and surfacing the track; also for making roads to ballast pits, and laying all surface tracks for getting, loading and unloading the ballast, placing the same in the road and trimming it up.

Ballast pits.

378 In selecting ballast pits a preference will always be given to those points where the best material can be procured, having due
379 regard to the convenience of the contractors. During the working of any pit, should the materials be found unfit for ballasting, the engineer shall have power to compel the contractors to close such pit and open others.

380 The surface of the ballast pits shall be stripped of soil other than gravel, where such exists, and the stripping hauled away by horses and carts to a spoil bank, as may be directed by the engineer,
Working. invariably keeping the pit stripped 10 feet back from its face, and no ballasting material whatever shall be placed on the road bed, but as good, clear gravel, free from earth, clay, loam or loamy sand, as the country will afford along the line or within practicable working distance from it by branch lines or sidings.

381 The maximum size of gravel must not be greater than three
382 inches in diameter. In unloading the ballast the train must be kept in constant motion, working to and fro so as to thoroughly mix different qualities of ballast, until a sufficient quality is deposited
383 for the first lift. The track must then be raised so that there will be an average depth of 6 inches beneath the ties, and they must be thoroughly tamped throughout their entire length with picks or bars and not only with shovels, and care shall be taken to keep large stones away from the ends of the ties.

384 As the raising proceeds, the end of the "lift" shall extend over not less than three rail lengths, and, before trains are allowed to pass over the inclined portion of track, it must be made sufficiently solid to prevent bending the rails or twisting the rail joints. After
385 the lift the track shall be centered, lined, topped, surfaced and trimmed off to a proper form and width. About 2,600 cubic yards of ballast, pit measurement, will be required for each mile of single track. Second "lift" must be made in the same manner and with the same precautions as required for the first "lift," in order to secure a thickness according to plan directions.

Extra ballast.

386 In wet cuttings the engineer shall have power to direct a greater thickness of ballast should it be deemed necessary.

INSPECTION.

All structural work, whether foundations, masonry, concrete, etc., timber or other work, will be carried out under the supervision of inspectors appointed by and acting under the authority of the engineer, whose duties will be to see that the requirements of the specifications and the instructions of the engineer are carried out, but their presence is in no way to be presumed to release in any degree the responsibility of the contractor or his obligations. 387

Inspectors.

All materials will be subject to rigid inspection, and any that have been condemned must be removed from the site of the work immediately. No masonry will be allowed to be laid in freezing weather except as directed by the engineer. 388

No masonry in frozen weather.

The rolling stock shall consist of:— 389

Passenger locomotive or locomotives.
Freight locomotive or locomotives.
Pulman sleeping car or cars.
Parlor car or cars.
Second class cars.
Composite cars.
Postal cars.
Box cars.
Baggage cars.
Platform cars.
Hopper cars.
Cattle cars.
Snow plows.
Hand cars.

Such as the engineer may, from time to time, order, but not later than months before the completion of the contract.

Turntables to be erected when required of a class and character approved by the engineer. 390

First class stations must have freight houses, coal sheds, wood sheds and tank houses detached. Second class stations to have a station and freight shed combined and coal and wood sheds where necessary. All, except flag stations, to have ample accommodation for the station agent to live in. At the terminal stations, engine, coal and car sheds will also be required, and tank houses must be erected at such stations as the working of the traffic may warrant. 391 392

Stations.

A plan and specifications of each class of station buildings, freight houses and wood sheds will be furnished by the engineer. 393

Stations will be built of sound, well-seasoned timber, on timber foundations and roofed with shingles and lined with felt, finished complete with locks, fastenings, hinges, doors and windows in each; 394

to have three coats of paint; the whole to be done in a workmanlike manner according to plans and specifications. The cost of timbed, plaster and shingles, as mentioned in the schedule, is to cover the whole cost of the building.

395 There will be engine sheds erected as may be hereafter arranged. They are to be sufficiently capacious to hold as many engines as the Company consider necessary, and to have wash-out pits with sufficient drainage leading therefrom.

396 Water supply, to the satisfaction of the engineer, to be provided at such point or points on the line as may hereafter be considered desirable.

397 Car sheds, coal sheds and engine houses will be built of sound timber with shingles.

MACHINE AND REPAIR SHOPS.

398 Such as may be ordered by the engineer shall be provided.